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On
Consumer Acceptance and Market Potential of Value-added Product Made from Lipoxygenase-free Soybean*

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Background and justification

Soybeans are one of the world's least expensive sources of high quality protein, vitamins and minerals. Although the soybean was introduced in the US as early as 1765, its potential as a protein source for feed and food was not recognized until the 1940s. However, soybean has been converted into many traditional Asian soy foods like soymilk and tofu. While any soybean variety can be used to make soymilk and tofu, certain varieties are preferred by processors due to their protein quality, flavor, and yield.

For years, vegetarians and health enthusiasts have known that foods rich in soy protein offer a good alternative to meat and other animal-based products. Recently, FDA approved the health claim for products high in soy protein have the benefit of lowering heart disease risk. In a survey conducted by the United Soybean Board, two-thirds of consumers surveyed believe soy products are "healthy." As consumers have pursued healthier lifestyles in recent years, consumption of soy-based foods has risen steadily. Although consumers are ready to acknowledge the "healthy" aspects of soy consumption, the "beany taste" and "gritty mouthfeel" have limited widespread consumption of soy based foods. Americans are also not ready to make massive lifestyle changes and only 15 percent of the consumers indicated that they eat a soy product once a week. One of the reasons is the negative conception or experiences with the taste and texture of soybeans.

The undesirable flavors most frequently associated with soybean based products have been characterized as beany, green, grassy, and bitter and is due to the presence of Lipoxygenase (LOX) in soybeans. LOX produce off-flavors in soybeans by hydroperoxidation of fatty acids and by interaction with protein in flours, concentrates, and isolates. Normal soybeans contain three LOX isozymes (SBL-1, SBL-2, and SBL-3). These three isozymes have been associated with the production of hexanal and other aldehydes, and ketones that contribute to off-flavor. Hexanal is a breakdown product of the hydroperoxides produced from oxidation of linolenic and linoleic acids which have been linked as the main undesirable flavor compound of soybeans. The off-flavor characteristics are especially prominent in soymilk and soymilk based products. Recent discoveries in biotechnology and agronomy have helped in finding manipulated breeding and hybridization techniques to grow "specialty use" soybean varieties. These special varieties of soybeans are free of all the three LOXs responsible for the off-flavors invariably present in soybeans.

The L-Star soybean, a new variety of soybean, was developed in 1990 by the National Agricultural Research Organization of the Ministry of Agriculture, Forestry and Fisheries (NARO) in Japan. In November 2003, The Georgia/Florida Soybean Association obtained the rights to grow this new soybean variety in the U.S. This variety is adapted to Zone 7, which includes Georgia, due to its date of maturity. L-Star soybeans have a milder flavor and more pleasing aroma than common U.S. and Asian-grown varieties due to the removal of all LOX from the traditional soybeans by traditional breeding methods. Thus, L-Star soybean is not a GMO, making it suitable for use in the U.S. and throughout the world. Hence, the production of LOX free soybean will have better market acceptability and thereby, benefit the farmers of Georgia. The company will have contract with farmers to produce this variety, to be used only for human food, and will pay a premium for it. Of course, soybean buyers must determine seed quality at point of purchase. The society of commercial seed technologies has described a procedure which is followed by buyers to check the quality of soybean seeds. Now, with addition of this new variety of soybean free from LOX, one more step is required to be added for analysis of the seed quality. This step is to check the presence of LOX in the seed. There is a need to develop a simplified method for detecting LOX as farmers and buying point workers are unlikely to have access to elaborate lab facilities. The desirable assay should not be time consuming since it may be necessary to test many samples per day, and must be robust to eliminate chances of cross contamination. The test must also be simple and also cost effective.

Soymilk made from soybeans lacking LOX had less volatiles including hexanal, 1-penten-3-ol, 2-hexenal, 2-pentylfuran, and others. The basic idea of developing these kinds of soybeans is utilization in soymilk and related soy-based products with no or very much less off-flavor characteristics. Combining these attributes with recent FDA studies linking soybean consumption to reduced risk of heart disease, demand of food-grade soybeans is expected to increase and make L-Stat a valuable cash crop.

How the issue or problem was approached via the project

The overall objective of the proposed study was to develop testing protocols and specifications to ensure the L-Star soybean variety grown in the U.S. have the same desirable quality attributes as in Japan and develop soybean-based products from L-Star soybean acceptable by the consumers in the U.S. Specific objectives were: (1). Establish production, storage, seed conditioning, processing, and testing protocols and levels of inspections, audits, and acceptance levels for the new LOX-free soybeans, (2). Develop a value-added soybean based product (soymilk) from the new LOX-free soybean flour, (3). To determine the consumer acceptability and market potential of soymilk made from the new LOX-free soybean.

Objective 1.

The presence or absence of LOX can be readily and accurately determined by the sodium dodecyl sulfate-polyacrylamide gel electrophoresis method, absorbance changes at 234 and 280nm; by polarographic; and by immunological techniques. However, these methods are time-consuming, requires a number of manipulation for determination, and they cannot be performed in the field without expert guidance. On the other hand, a dye solution method is a very powerful detection technique and applicable to a visual judgment in the field or at buying points. There are studies done by other scientists dealing with dye solution bleaching by soybean LOX. However, these tests involved complex procedures and careful handling for detection of LOX-1 or LOX-2 isozymes in soybean lacking LOX-3 isozymes. Other study also reported color tests based on the oxidation of iodine starch for the LOX-1 isozyme or ferrous thiocyanate for the LOX-2 or LOX-3 isozyme. However, the weakness of the test was that the test for LOX-3 was valid only in absence of LOX-2 and also required time consuming manipulations.

A spectrophotometric method for the selective detection of individual LOX isoenzymes in soybean seeds, based on the different bleaching ability of LOX-1 (test 1) and LOX-2 (test 2) against methylene blue, and LOX-3 (test 3) against β–carotene has been reported. In case of test 1, the mixture appears to be blue in color. However, on adding the seed containing LOX-1 to it, the solution turns colorless. Similarly the solution turns from light blue to colorless on presence of LOX-2 and test 3 turns from orange to colorless in presence of LOX-3. However, these tests involve complex procedures and careful handling for detection of the LOX-1 or LOX-2 in seed lacking the LOX-3 isozyme. Also, an additional drawback of this method was that it could not be practiced in field, on day to day basis. The authors also proposed a visual method with a slight modification of the spectrophotometric method, which is used for routine screening technique. Although simpler than the spectrophotometric method, this visual method still required preparing multiple reagents and weighing out mg quantities of soybean seed. A simplified version of this test, in which consistent volumes of reagent were used for each test, was suggested. Here, a quick and simple visual method for the selective detection of LOX isoenzymes in soybeans was developed from the current study. The method is based on differential bleaching ability of LOX-1, LOX-2 and LOX-3 isoenzyme in contact with methylene blue and b-carotene. We have modified the earlier suggested methods based on stability of reagent and focused on elimination of possible cross contamination and false results in field conditions i.e. contamination of LOX free soybean seed by LOX soybean seed or vice versa. The purpose of this modification was to derive a method that will be convenient for the farmers in the field or the buying point worker to test the presence of LOX in seed.

Studies for objective 1 were carried out in four phases. In Phase I, the reliability and reproducibility of existing LOX assays were determined. In Phase II, the use of an entire, crushed soybean was investigated to eliminate weighing small samples. In Phase III, stability of the reagents required for the assay was determined. In Phase IV, various approaches to simplifying the method for use by non-technical personnel were investigated.

Soybeans: One sample of a standard soybean variety (Benning) and 6 samples of L-star variety of soybean seed were used.

Reagents: Linoleic acid(99%), β-carotene(80-90%), methylene blue and dithithretiol were from Sigma Chemical Co., St Louis, Mo.

Preparation of Substrate: Sodium linolate substrate was prepared from linoleic acid. Briefly, 70mg of linoleic acid and 70mg of tween 20 were mixed in 4 ml of boiled, deionized water by drawing the mixture back and forth in a Pasteur pipette, avoiding bubbles. An aliquot of 0.55 mL of 0.5 N NaOH was added and made volume to 25 ml with distilled water. The solution was placed into vials and purged with nitrogen gas.

Preparation of β-carotene at 50% saturation in acetone: About 10 mg of β-carotene was added to 10 mL of acetone and vortexed. It was then centrifuged; the orange-colored supernatant was decanted from undissolved solids at the bottom of the test tube.

Visual judging method for detecting Lipoxygenase Isoenzyme: The three LOX isozymes were each detected using the following tests.

Test-1 (LOX-1 lipoxygenase): The reaction mixture contained 25 ml of 200mM of sodium borate buffer (pH-9), 5 ml of methylene blue (100uM), and 5 ml of sodium linolate substrate (as prepared above) and 5 ml of distilled water. Now 2 ml of the above composition was added to sample to which 0.5 ml of distilled water had been added. It was then allowed to stand for 2-3 min and color change was observed.

Test-2 (LOX-2 lipoxygenase): The reaction mixture contained 25 ml of 200mM of sodium phosphate buffer (ph-6), 5 ml of methylene blue (100uM), 5 ml of sodium linolate substrate (as prepared above), 5 ml of acetone, 154 mg of dithiothreitol and 5 ml of distilled water. Now 2 ml of the above composition was added to sample to which 0.5 ml of distilled water had been added.

Test-3 (LOX-3 lipoxygenase): The reaction mixture contained 25 ml of 200mM of sodium phosphate buffer (ph-6.6), 5 ml of 50% acetone saturated β-carotene, 5 ml of sodium linolate substrate (as prepared above) and 5 ml of distilled water. Now 2 ml of the above composition was added to sample to which 0.5 ml of distilled water had been added. It was then allowed to stand for 2-3 min and color change was observed.

Objective 2.

The low fat L-Star flour received from the American Soy & Tofu Corporation was used for the studies. Flour was further dry milled in either a Morehouse mill or a super wing mill to achieve various particle sizes. Soy flour then mixed with appropriate amount of water and homogenized at room temperature at pressure of 3,000 to 5,000 psi and slurry were passed once, thrice, and five times through the homogenizer. Effect of filtration through 273 mesh polyester filter screen was evaluated. The homogenized slurry was then cooked and then formulated with sugar, emulsifier, and stabilizer in a steam kettle at 75-85ºC with constant stirring. The formulated liquid mixture was then homogenized again (at 3,000 to 5,000 psi) for two to three passes. A three member professional team of judges (Composed of Dr. Hung, Dr. Phillips and Dr. Resurreccion) conducted an informal evaluation of mouth feel and flavor of the prepared soymilk samples. The stage 1 part of the processing conditions for formulation optimization was identified as:

- Add 175 to 375 g of soy flour into 4800 ml water
- Mix with a hand-held blender till completely dispersed
- Homogenize five (5) times at 5000 psi pressure
- Add 3 % sugar, 0.1 to 0.2% of carageenan, 0.1% salt, and 1% calcium carbonate.
- Heat to a temperature of 85^{o}C
- Homogenize three (3) times at 5000 psi pressure

We have also decided not to filter the drink in order to retain all the nutrients. Nine different formulations based on 3 levels of soy flour (175, 275, 375g) and 3 levels of stabilizer (0.1, 0.15, 0.2% carageenan) were prepared and the rheological property, color, stability, composition, and consumer sensory evaluation were conducted.

Further formulation optimization was conducted to enhance the soymilk stability, color, and sensory quality based on the stage 1 part of the consumer sensory evaluation results. Calcium phosphate was selected to replace calcium carbonate and cyclodextrin was added.

The stage 2 part of the processing conditions for formulation optimization was identified as:

- Add 100 to 300 g of soy flour into 4800 ml water
- Mix with a hand-held blender till completely dispersed
- Homogenize five (5) times at 5000 psi pressure
- Add 3 % sugar, 0.2% of carageenan, 0.1% salt, 0.5 to 1% calcium phosphate and 0.3% cyclodextrin.
- Heat to a temperature of 85^{o}C
- Homogenize three (3) times at 5000 psi pressure

Nine different formulations based on 3 levels of soy flour (100, 200, 300g) and 3 levels of calcium phosphate (0.5, 0.75, 1%) were prepared and the rheological property, color, stability, composition, and consumer sensory evaluation were conducted.

Objective 3.

A 2-stage optimization sensory test with 30 panelists/consumers was conducted. The first stage optimization sensory test was conducted using 30 panelists to identify optimum levels of soy flour and stabilizer of the soy milk. Attempts were made to recruit equal numbers of each gender and to balance age groups. Samples prepared in a 3 x 3 factorial design were varying in levels of soy flour and stabilizer. Two ounces of each sample were served in 6-oz clear translucent plastic glasses. Samples were received in the sensory laboratory during the morning of the test date. They were stored in the refrigerator and only samples to be used for a session were brought to the sensory laboratory, in an insulated container, to prevent samples from warming. Each sample was presented to panelists identified only by a 3-digit code.

The sensory tests were held in the Consumer and Sensory Science laboratories of the Food Science Building, University of Georgia Agricultural Experiment Station in Griffin. A total of four sessions were conducted throughout the day with a maximum of 10 panelists participating in each session. Session times were spaced at least an hour apart (10:00, 11:30, 2:00 and 4:00). On arrival at the testing site, panelists were greeted and oriented in a conference room area. During the orientation, panelists were given instructions on how to use the sensory booth lights and were briefed on the computer ballots. Time was allowed for questions to be asked, if any. The panelists were then led to the booth area by the greeter and seated in the sensory booths.

Ten samples (nine treatments and a control consisting of a regular commercial soymilk) were presented to panelists, in a sequential monadic, balanced order of presentation over two testing sessions, separated by a rest period. The order of sample presentation was designed to minimize presentation order bias. Panelists rated each sample for overall acceptance and acceptance of the attributes: appearance, color, flavor, sweetness and mouthfeel/body/texture using a 9-point hedonic scale on which 1=dislike extremely, and 9=like extremely. Panelists indicated their acceptance ratings for each attribute listed for each sample on computer ballots. There was a rest period of 5 min between the fifth and sixth sample evaluated to prevent panelist boredom. After all samples were presented and evaluated, consumers filled out a demographic questionnaire. An honorarium of $10 was provided as an incentive for participation in the study.

Mean consumer acceptance ratings were calculated for the attributes; appearance, color, flavor, sweetness, texture/mouthfeel, and overall acceptance of each sample. Analysis of variance was performed to determine any significant differences between attribute ratings of each sample.

Results of the 1^{st} stage optimization sensory testing was then used to define the levels to test in a 2^{nd} stage refined optimization sensory testing. The second stage optimization sensory test was conducted using 30 panelists to identify optimum levels of soy flour and calcium phosphate of the soy milk. Samples prepared in a 3 x 3 factorial design with levels of calcium phosphate of the soy milk were 0.5, 0.75, 1%, and levels of the soy flour were 100, 200, and 300 g. Same sensory evaluation procedures described above were followed.

Best formulation identified from the 2^{nd} stage refined optimization sensory evaluation was used for in-store evaluation/promotion to be conducted by the Georgia Department of Agriculture. Survey results were used to randomly gauge public reception of the soy milk.

Contribution of public or private agency cooperators

Soybean materials were supplied by the Georgia/Florida Soybean Association and American Soy and Tofu Cooperation. They also provide signification contributions on methodologies and provide advice for fine tuning our research plan.

American Soy and Tofu Cooperation also actively participated the sensory evaluation to identify the formulation for the market potential survey.

The Department of Marketing & International Trade of the Georgia Department of Agriculture provide inputs through out the whole project period on market potential of soymilk made from LOX-free Soybean.

Results, conclusions, and lessons learned

Objective 1

Phase 1. The repeatability of the two existing LOX assays to measuring the three isozymes was tested by repeating the tests over several days. Both produced reproducible results: Benning variety of soybean invariably produced a positive test (methylene blue and β-carotene were bleached); while L-Star samples from various locations always gave a negative result. Based on equal reliability of the two existing methods, the National agriculture research culture approaches was chosen for further modification due to its relative simplicity.

Phase II. The sample size was modified. As our target group was farmers and buying point operators, our focus was to eliminate the weighing of sample to be tested. Here, we tried to find which of the following sample (I.e. crushed seed, whole seed or whole scraped seed) was most reliable sample selection method. It was found that quantity tested didn't affect the test result. However, the crushed seed gave consistent result. This meant that weighing out a small amount of seed or even trying to select approximately the same amount for each test was not necessary. Simply crushing a single whole bean and introducing it into the reagents produced reliable results.

Phase III. This phase was done to check the stability of all the reagents used for the three tests. It was observed that apart from B–carotene, all other reagents have an acceptable shelf life. Linolate is highly unstable, but if stored in small values treated with nitrogen it may be stored for an extend time. B-carotene was highly unstable, suggesting that it would have to be made fresh daily. The main focus of this study was to provide simple method, we showed that allowing the solids in a saturated solution of carotene to settle overnight and drawing off an aliquot of the clear supernatant was as effective as centrifugation.

Phase IV. This phase was done to simplify the method. Premixing all reagents in the proper amounts and storing them prior to use was examined. This was partially successful for Tests 1 and 2 where the color reagent was methylene blue, although it took longer for the test to work with storage. For test 3, B-carotene was not sufficiently stable to allow this approach to work.

Objective 2

In study I, the moisture and ash contents decreased with increasing soy flour while oil and protein content increased with increasing soy flour (Table 1). In general, the amount of stabilizer had no effect on the chemical composition of soymilk. Control commercial sample had protein content similar to the soymilk containing 375 g soy flour. However, it had significant higher fat content (4.1%) than all other soymilk samples (0.1 to 0.2%). Viscosity of soymilk increased with increasing soy flour and stabilizer and sample 9 was the most viscous sample. Commercial soymilk had viscosity similar to sample 1.

Table 1. Chemical composition and viscosity of soymilk from Study I.*

Sample Number	Soy flour (g)	Stabilizer (%)	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Viscosity (cP)
1	175	0.1	92.30	17.80	0.15	20.44	9.72
2	275	0.1	91.16	15.88	0.18	30.02	12.40
3	375	0.1	89.15	13.41	0.20	32.20	26.20
4	175	0,15	92.57	17.37	0.10	21.72	7.60
5	275	0.15	90.91	14.91	0.07	28.44	33.90
6	375	0.15	89.05	13.38	0.15	31.39	37.50
7	175	0.2	92.35	17.04	0.10	23.26	17.40
8	275	0.2	90.87	15.23	0.08	26.61	29.90
9	375	0.2	89.03	13.45	0.11	30.79	65.60
Control			91.80	8.61	4.31	31.84	9.42

* All soymilk samples were made with 4800 ml water and control sample was a commercial organic soymilk sample. Protein, fat and ash content are expressed on dry-weight basis and carbohydrate content in % can be calculated as 100 – (protein+fat+ash).

In study II, the moisture and ash contents decreased with increasing soy flour while protein content increased with increasing soy flour (Table 2). In general, the amount of added calcium had no effect on the chemical composition of soymilk except ash content. Control commercial sample had protein content higher than all other soymilk samples and had significant higher fat content (2.97%) than all other soymilk samples (0.1 to 0.2%). Viscosity of soymilk increased with increasing soy flour and commercial soymilk had viscosity similar to sample 1.

Table 2. Chemical composition and viscosity of soymilk from Study II.*

Sample Number	Soy flour (g)	Calcium (%)	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Viscosity (cP)
Control			91.68	8.26	2.97	34.25	5.1
1	100	0.5	93.91	11.978	0.16	17.48	7.95
2	200	0.5	92.90	10.97	0.22	26.33	13.7
3	300	0,5	90.62	9.99	0.12	31.43	26.8
4	100	0.75	93.95	15.38	0.14	17.40	9.05
5	200	0.75	92.36	13.23	0.13	25.83	16.9
6	300	0.75	90.46	12.00	0.10	31.12	26.9
7	100	0.1	93.96	18.63	0.14	17.68	9.05
8	200	0.1	92.04	14.04	0.02	23.63	15.6
9	300	0.1	89.85	12.40	0.01	29.66	19.9

* All soymilk samples were made with 4800 ml water and control sample was a commercial organic soymilk sample. Protein, fat and ash content are expressed on dry-weight basis and carbohydrate content in % can be calculated as 100 – (protein+fat+ash).

Objective 3

Table 3. Means of consumer ratings for soymilk (Study I).*

Sample**			Sensory Ratings					
Number	Soy flour (g)	Stabilizer (%)	Appearance	Color	Flavor	Sweetness	Texture	Overall Acceptance
1	175	0.1	5.77a	5.83a	5.27ab	5.57ab	6.00ab	5.07ab
2	275	0.1	6.00a	5.93a	4.70b	5.20ab	5.53ab	5.00ab
3	375	0.1	5.90a	6.17a	5.13ab	5.43ab	5.43ab	4.60b
4	175	0,15	5.77a	5.93a	4.87b	5.17ab	5.60ab	4.63b
5	275	0.15	5.83a	6.07a	4.50b	5.37ab	5.30ab	4.57b
6	375	0.15	5.77a	5.87a	4.67b	5.10ab	5.37ab	4.60b
7	175	0.2	6.10a	6.23a	5.50ab	5.53ab	5.67ab	5.13ab
8	275	0.2	6.07a	6.10a	4.73b	5.13ab	5.30ab	4.37b
9	375	0.2	5.83a	5.80a	4.33b	4.80b	4.93b	4.07b
Control			6.57a	6.47a	6.10a	6.13a	6.40a	6.03a

* Mean values in a column not followed by the some letters were significantly ($P \leq 0.05$) different
** All soymilk samples were made with 4800 ml water and control sample was a commercial organic soymilk sample

In sensory study I, there were no significant differences in the mean ratings for appearance and color (Table 3). Mean appearance acceptance was rated 'like slightly or higher ($\geq$6.0) for samples 2, 7, 8, and control. All other samples were rated 'neither like nor dislike' and ranged from between 5.77 to 5.90. Color acceptance was rated 'like slightly or higher ($\geq$6.0) for samples 3, 5, 7, 8, and control All other samples were rated between 5.80 and 5.93.

The commercial control was the only sample rated ‘like slightly’ (> 6.0) for flavor, although these were not significantly different from samples 1, 3 and 7. Samples 2, 4, 5, 6, 8 and 9 were rated significantly lower in flavor than the control. Sample 9 had the lowest rating of 4.33. Only the control sample was rated >6.0 for sweetness acceptance and soymilk samples 1 through 8 were not rated significantly different than the control. Texture acceptance was high for the control sample (= 6.4), but its rating was not significantly different from samples 1 through 8 which were rated between 5.30 and 5.67. Overall acceptance rating was highest for the control sample only. However, overall acceptance of the control was not significantly different from overall acceptance of samples 3, 4, 5, 6, 8 and 9.

Table 4. Means of consumer ratings for soymilk (Study II).*

Sample**			Sensory Ratings					
Number	Soy Flour (g)	Calcium (%)	Appearance	Color	Flavor	Sweetness	Texture	Overall Acceptance
Control			5.53abc	5.43abc	5.33a	5.30a	5.60a	5.17a
1	100	0.5	4.70c	4.70c	4.47a	4.83a	4.83a	4.63a
2	200	0.5	5.23bc	5.30bc	4.83a	5.13a	5.23a	4.90a
3	300	0.5	5.63abc	5.47abc	5.07a	5.40a	4.97a	4.97a
4	100	0.75	5.47abc	5.50abc	5.27a	5.33a	5.33a	5.20a
5	200	0.75	5.73abc	5.67abc	5.10a	5.30a	5.37a	5.10a
6	300	0.75	5.90ab	5.87ab	4.90a	5.20a	4.90a	4.90a
7	100	1.0	6.13ab	6.07ab	5.27a	5.47a	5.50a	5.33a
8	200	1.0	6.33a	6.40a	5.17a	5.30a	5.37a	5.47a
9	300	1.0	5.90ab	6.00ab	4.77a	4.97a	5.17a	4.77a

* Mean values in a column not followed by the some letters were significantly ($P \leq 0.05$) different

** Control - commercial organic soymilk. Other soymilk samples were made with 4800 ml water.

For sensory study II, soymilk 8 had the highest ratings among all samples including control, and was not significantly different from the control and soymilks 3, 4, 5, 6, 7, and 9 (Table 4). Soymilk 8 appearance ratings were significantly higher than those of soymilks 1 and 2. Soymilk 1 received the lowest rating for appearance of 4.70, which was significantly lower than the control sample and soymilks 6, 7, 8 and 9. Soymilk sample 8 had the highest rating for color. Sample 8 ratings for color were significantly higher than those of samples 1 and 2 only. Only sample 1 had a rating less than 5 or ‘like slightly.’ Flavor acceptance ratings of all samples, including control, were not significantly different, and ranged from 4.47 to 5.33. The highest ratings were given to the control followed by soymilk 7 and the lowest to soymilk 1. Sweetness acceptance ratings ranged from 4.83 to 5.47. However, ratings were not significantly different from each other. The control sample was rated 5.30. Samples 3, 4, 5, 7 and 8 were rated equal to or higher than the control. For texture, the control sample was rated 5.60. All other samples were rated lower than the control on texture and ranged from 4.83 to 5.50 for acceptance of texture. The control sample was rated 5.17 for overall acceptance. Samples 4, 7 and 8 were rated higher than the control. Analysis of variance indicated no significant differences between samples for overall acceptance.

Best formulation identified from the 2nd stage refined optimization sensory evaluation (formulation #8) was identified for in-store evaluation/promotion to be conducted by the Georgia Department of Agriculture. However, due to personnel changes at the Georgia Department of Agriculture this part of the objective was eliminated from the overall objective of the project.

Suggestions for further research needed, if applicable.

Further research and development activities are:

Objective 1:

1. Additional attempts to incorporate all of the reagents for a single test into a single test tube which can be held and remain stable for an extended period of time.

2. Apply these tests to a wider range of soybeans, including those known to contain all possible combinations of LOX isozymes.

3. Produce and distribute test kits which may be provided to producers, buyers, warehouse operators, and processors of soybeans for quickly, easily, and reliably testing soybean seeds for LOX, thus validating the identity of L-Star beans.

4. Complete a protocol by which minimally trained individuals at buying points will be able to reliably test incoming lots of soybean seeds for LOX.

5. Train personnel to test soybeans for LOX using the protocol developed in 3, and validate the results by challenging them with test seeds known to be positive and negative for LOXs.

We have recently received a grant from the GACC for soybeans of $2,500 to pursue some of these goals.

Objectives 2 & 3:

1. To develop a ready to mix soymilk powder. It will have the advantage of convenience and shelf stable.

2. To develop other soy based value added products using whole L-Star soybeans.

Current or future benefits to be derived from the project.

Implementing the testing protocol described above will ensure the reliable availability of L-Star soybeans for food processors, and improve the consumer acceptance of soy-based foods. Soymilks developed from this project have equal or better sensory quality attributes than the commercially available soymilk but with better nutritional quality due to using the whole soybean for the process.

Additional information available (e.g. publications, web sites).

- New "deodorized" soybean to rid soy of "beany" taste. March 8, 2006. http://www.foodnavigator-usa.com/news/ng.asp?id=66307
- Putting taste first. Feb. 13, 2006. Griffin Daily News.
- Take a modern look at this hot bean. March 29, 2006. Athens Banner-Herald.

Scientific publication is in preparation.

Major project beneficiaries.

Several soy milk manufacturers have been contacted and American Soy & Tofu Corporation is in the process of identifying a company to manufacturing the soymilk developed from the project.

Consumer in general will be benefited because they will more likely to consume this whole bean soymilk if object ional beany flavor is not present.

Contact person for more information.

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